Distributed Generation Systems

Program Mission

Distributed Generation Systems: Fuel Cells: The objectives of the Fuel Cell activity are ((1) to provide the necessary technology base development of fuel cell systems for electric utility, industrial, and commercial/residential markets; and (2) to provide technologies that improve U.S. international competitiveness in this new manufacturing industry. Fuel cells and other innovative power systems are being developed for distributed generation applications that can create public benefits by enhancing the overall efficiency, security and reliability of the Nation's energy supply. The Fuel Cells Program supports the President's climate change goals by increasing the efficiency of electricity production, creating the potential for over 50% reduction in CO_2. Further, it supports the Clear Skies Initiative with near zero NO_x, SO_x, and mercury emissions, and it supports energy security goals through multi-fuel capability (less dependence on one fuel), and less vulnerable distributed generation.

To complement electricity supply from central generation systems, distributed systems offer another form of energy diversity through smaller-scale production of electric power in stationary plants at or near the end user. Fuel cells as small modular resources may be used on a stand-alone basis, or integrated with other generators, and even connected to a central system grid. These systems may be owned and/or operated by utilities, utility customers, and third parties. Fuel cell systems are capable of reducing criteria pollutants well below current New Source Performance Standard levels, reducing non-criteria pollutants such as CO_2 and acid rain precursors, and reducing thermal emissions to the environment. Fuel Cells are important systems for carbon management options because of their inherently low emissions and ultra-high efficiency.

Fuel cell applications in distributed generation systems offer potential opportunities for cost-effectively meeting peak demand without the need for costly investments in transmission and distribution. They can be used to provide clean power to remote end users; and can provide new business opportunities in both utility and non-utility owners.

The Fuel Cells Program is leveraging technical innovation to develop advanced power systems for distributed generation that will improve power quality, boost system reliability, reduce energy costs, and help delay/defray capital investments. The program goal is to develop low-cost, high efficiency, fuel flexible, modular power systems with lower cost, higher quality electricity, and significantly lower carbon dioxide emissions than current plants, as well as near-zero levels of pollutants.

The current strategy is to develop clean high efficiency fossil fueled powerplants: Near-term (2004-2006) - develop and conduct initial proof-of-concept tests of the Solid State Energy Conversion Alliance (SECA) low-cost, 3-10 kilowatt solid-state fuel cell modules for distributed and auxiliary power unit applications; Mid-term (2010) - develop and test SECA fuel cell prototype modules capable of manufacture of $400 per kilowatt (a ten-fold reduction from today's cost), and develop combined cycle $400 per kilowatt gas-based fuel cell/turbine hybrids under Vision 21 Hybrids that will enable the design of coal-fueled hybrid powerplants; Long-term (2010-2015) - develop and demonstrate the critical high risk technology advancements which will permit U.S. industry to establish commercial availability of advanced, low-cost, ultra-high efficiency, fuel flexible, integrated fuel cell/turbine hybrids systems

for natural gas and coal-based plants. Fuel cell systems have specifically identified goals which coincide with coal-based and other fuel-flexible Vision 21 power modules and concepts in the 2010 to 2015 time frame.

The Advanced Research subactivity within the Fuel Cell program supports the program objectives by conducting research to identify new, highly innovative electrochemical technology concepts and by solving fundamental crosscutting high-temperature electrochemical issues. This subactivity also supports SECA core technology materials work and direct carbon fuel cells.

With the conclusion of molten carbonate fuel cells stack development in FY 2003, the Fuel Cell Systems subactivity will support advanced fuel cell systems development and testing in a variety of crosscutting areas.

The Fuel Cell/Turbine Hybrids subactivity under Vision 21 provide a rapid way to deploy the fuel cell technology into broader applications. Integration of the fuel cell and turbine into a single system lowers system costs and raises system efficiency. Hybrid efforts include dynamic and detailed modeling, small scale system testing, continued system studies and exploration of integration and market issues. Hybrid power modules are expected to be a key enabling technology for long-term Vision 21 systems. Hybrid power modules are important element of the Department's policy for carbon management.

The Innovative Concepts subactivity includes the Solid-State Electricity Conversion Alliance (SECA), a new paradigm for fuel cells development. The objective of the SECA is to drastically reduce fuel cells costs to make them a broadly applicable and more widespread commodity in the competitive, mature distributed generation and auxiliary power markets. The SECA program incorporates an integrated strategy to address the technical barriers of solid-state fuel cell systems within the cost constraint of $400 per kilowatt for a complete system. The project global benefits of SECA includes 0.24%-0.5% reduction in the U.S. CO_2 emissions projected by EIA in 2012, which corresponds to about 42 million tons per year in CO_2 reduction. Additional management benefits can be expected to accrue with the introduction of SECA hybrid systems. Work under SECA core program includes, gas processing (reforming and cleanup), power electronics, controls and diagnostics, heat recovery, modeling and simulation, and material and manufacturing/ fabrication research at universities and national laboratories. SECA industry teams are engaged in the development of common modules for diverse applications in multiple and mobile market applications. SECA includes exploration of designs that combine functions to reduce size, weight, and costs.

The government's industrial partnerships in the SECA program can be expected to provide the following benefits within the next ten years, if the $400 per kW target is achieved:

- World-wide sale of $3.2 billion per year, including domestic sales of $1 billion per year based on a 10% share of expected electricity demands.
- The potential to provide domestic fuel cell to a market of 25 million homes in the U.S. and 50 million homes in Europe.

- Approximately $800 million per year from the sale of auxiliary power units for trucks, which can substantially reduce the emissions from idling trucks engines.
- Virtual elimination of NO_x from stationary and transportation applications, and 50% reduction of CO_2 through the use of highly efficient (60%) hybrid fuel cell systems.

Novel Generation Concepts: The Fossil Energy R&D program is committed to searching for promising new ideas for low-cost, low-pollutant power generation. In recent years, Fossil Energy R&D has funded research on the Ramgen engine, an innovative power systems technology. The Ramgen system is capable of utilizing a variety of fuel gases including waste gases, and components show potential for adaption to other power systems. To ensure the participation of high-potential technologies, the power systems group will continue to openly solicit new fossil-fuel based power generation technology that shows promist of improved efficiencies and/or lower emissions through the novel concepts program.

Program Strategic Performance Goals

ER 4-4: BY 2010, increase the robustness of distributed generation and thereby lower vulnerability of the electricity grid by introducing prototypes of: a) modular fuel cells with 10-fold cost reduction ($400/kW) with 40-50 percent efficiency; b) fuel cell-turbine hybrids with 60-70 percent efficiency adaptable for coal.

Annual Performance Targets and Results

FY 2002 Results	FY 2003 Updated Targets	FY 2004 Targets
Communicate fuel cell program objectives and results and conduct peer-reviews through conferences, workshops, and web-site tools. Restart and test the 220-kW hybrid solid oxide fuel cell (SOFC)-microturbine powerplant at the National Fuel Cell Research Center. If successful, this test will verify the commercial design for this particular SOFC technology for DG or CHP applications. Complete demonstration of a commercial-scale, 250 kW Molten Carbonate Fuel Cell (MCFC) power plant system. This test will verify the	Communicate fuel cell program objectives and results and conduct peer-reviews through conferences, workshops, and web-site tools. Manage the PSPG R&D portfolio through assessment of results and selection of new projects to fill portfolio gaps. Conduct field tests necessary to establish feasibility of high temperature fuel cell hybrids and novel systems, including design, procurement, construction, and testing. Conduct cost reduction R&D programs involving near-term developers, Siemens Westinghouse and Fuel Cell	Perform assessment of the merit and progress of (and plans for) activities in the fuel cell program for achieving the efficiency and cost objectives for advance power generation, using peer reviews, conferences, or workshops, and disseminate the objectives and results of the fuel cell activities, including web-site dissemination, for use and potential deployment application or technology innovation by industry and other researchers. Complete construction of two test units and detailed design of a third concept for later conduct of field tests necessary to

FY 2002 Results	FY 2003 Updated Targets	FY 2004 Targets
commercial design for the MCFC technology for the combined heat and power (CHP) or distributed generation (DG) market and, if successful will justify the construction of a MCFC manufacturing facility in the U.S.	Energy, for the fuel cells, including manufacturing and balance of plant (BOP) components. The SECA industrial teams shall conduct stack design and testing, including manufacturing approaches, and materials and balance of plant (BOP) systems optimization leading to the demonstration of prototypes. Conduct contracted and in-house SECA core technology of crosscutting and proof-of-concept R&D for transfer to one or more industrial teams, including know-how, patents, licenses, reports, papers in peer reviewed journals, etc.	establish feasibility of high temperature fuel cell hybrids and novel systems. These tests planned for FY2005 will prove feasibility of 60-70% hybrid systems for integration into Vision 21 power plants. Continue SECA industry teams' evaluations and testing (100 hour tests) of fuel cell stack designs, manufacturing methods, candidate materials, and balance of plant subsytems with potential for demonstration as integrated systems. This effort will lead to testing of prototypes capable of achieving SECA cost reductions and efficiency goals. Continue SECA Core Program to perform the transfer of patents, licenses, technical data, and other knowledge products resulting from fuel cell concept tests and supporting research to one or more SECA industrial teams. This technology transfer will aid SECA industry teams in achieving cost reduction and energy efficiency goals.

Funding Profile

(dollars in thousands)

	FY 2002 Comp. Approp.	FY 2003 Request	FY 2004 Base	FY 2004 Request	FY 2004 Request vs. Base	
					$ Change	% Change
Fuel Cells						
Advanced Research	$3,895	$3,000	$3,000	$10,000	$7,000	233.3%
Fuel Cell Systems	13,147	10,000	10,000	6,000	-4,000	-40.0%
Vision 21 Hybrids	13,152	11,500	11,500	5,000	-6,500	-56.5%
Innovative Systems Concepts	26,484	22,500	22,500	23,500	1,000	4.4%
Subtotal, Fuel Cells	56,678	47,000	47,000	44,500	-2,500	-5.3%
Novel Generation	0	2,500	2,500	2,500	0	0.0%
Total, Distributed Generation Systems	$56,678	$49,500	$49,500	$47,000	$-2,500	-5.1%

Funding by Site

(dollars in thousands)

	FY 2002	FY 2003	FY 2004	$Change	%Change
Argonne National Lab (East)	$1,000	$1,000	$1,000	$0	0.0%
National Energy Technology Laboratory	2,340	2,000	2,900	900	45.0%
Pacific Northwest Lab	4,771	3,500	4,250	750	21.4%
All Other	50,998	44,500	40,200	-4,300	-9.7%
Total, Distributed Generation Systems	$56,678	$49,500	$47,000	$-2,500	-5.1%

Site Description

Argonne National Laboratory (East)

The Argonne National Laboratory (ANL), located in Argonne, Illinois, is a major multi-program laboratory managed and operated for the U.S. Department of Energy (DOE) by the University of Chicago under a performance-based contract. Argonne research for the Fossil Energy Distributed Generation Systems program supports the DOE-SECA core technology program.

Pacific Northwest Laboratory

The Pacific Northwest Laboratory (PNNL), located in Richland, Washington, conducts research and development in the area of Distributed Generation Systems in support of the DOE-SECA program. PNNL is a major participant in the Solid State Energy Conversion Alliance.

National Energy Technology Laboratory

The National Energy Technology Laboratory (NETL), located in Morgantown, West Virginia, Pittsburgh, Pennsylvania, and Tulsa, Oklahoma, is a multi-purpose laboratory, owned and operated by the U.S. Department of Energy. NETL conducts and implements science and technology development programs for the Department in energy and energy-related environmental systems. NETL's key functions are to shape, fund, and manage extramural (external) RD&D projects, conduct on-site science and technology research, and support energy policy development and best business practices within the Department.

All Other

The Department's Distributed Generation Systems program, within the Fossil Energy and Development program, funds research at major performers at non-DOE locations. Examples of these performers include the SECA industry teams and SECA core technology teams.

Detailed Program Justification

(dollars in thousands)

	FY 2002	FY 2003	FY 2004
Fuel Cells	**56,678**	**47,000**	**44,500**

The focus of the Fuel Cells program is to develop, for widespread deployment, clean realiable fuel cells and fuel cell hybrids for distributed generation and Vision 21 applications through low-cost, ultra-clean, and ultra-high efficiencies.

Advanced Research	**3,895**	**3,000**	**10,000**
■ **Advanced Research**	3,855	2,970	9,900

Fund research to develop a fundamental understanding of processes that limit the performance of high temperature electrochemical systems. Such systems have applications in fossil energy conversion, energy storage, and electrolysis. Parallel experimental and modeling activities, research conducted by HiTEC will eventually lead to new concepts and technologies in fossil fuel utilization. *Participants to be determined.*

FY 2003 and FY 2002 funding continued generic research to capitalize on the intrinsic high efficiency and environmentally benign characteristics of advanced electrochemical technology. Research will be conducted to identify new highly innovative electrochemical technology concepts and to solve fundamental crosscutting issues. *Participants included: ANL, PNNL.*

■ **Program Support**	40	30	100

Fund technical and program management support.

Fuel Cell Systems	**13,147**	**10,000**	**6,000**

	(dollars in thousands)		
	FY 2002	FY 2003	FY 2004
■ **Fuel Cell Systems**	13,012	9,900	5,940

With the conclusion of molten carbonate fuel cells stack development in FY 2003, this subactivity will support advanced fuel cell systems development and testing in a variety of crosscutting areas in FY 2004.

FY 2003 and FY 2002 funding continued cost-shared cost reduction and performance improvement on one full molten carbonate system for market entry by the private sector; continue supportive distributed generation infrastructure, economic and market study assessments and system assessments and evaluations. *Participants included: FCE.*

■ **Program Support**	135	100	60

Fund technical and program management support.

Vision 21 Hybrids	**13,152**	**11,500**	**5,000**
■ **Vision 21 Hybrids**	13,017	11,385	4,950

Conduct a redirected Vision 21 enabling cost reduction and performance enhancement program with low-cost Vision 21 fuel cell/turbine hybrid technologies; explore Vision 21 zero-emissions system concepts; conduct system studies and explore fuel flexibility and integration issues as permitted. *Participants include: NETL, GE, FCE, Siemens*.

FY 2003 and FY 2002 funding continued a Vision 21 enabling cost reduction and performance enhancement program with Vision 21 fuel cell/turbine hybrid technologies, such as the tubular SOFC hybrid; conduct system studies and explore fuel flexibility and integration issues as permitted. *Participants included: SWPC, NETL, GE, FCE.*

■ **Program Support**	135	115	50

Fund technical and program management support.

Innovative Systems Concepts	**26,484**	**22,500**	**23,500**
■ **Innovative Systems Concepts**	26,213	22,275	23,265

SECA - Develop four concept designs for prototype mid- to high-temperature low-cost solid state fuel cell systems; develop SECA core technology for materials to reduce manufacturing costs, enhance performance, and develop innovative sensors and converters; initiate designs of hybrid coal-based SECA systems. *Participants include: GE/Honeywell, Siemens Westinghouse, Delphi, Cummins-McDermott, PNNL, NETL.*

FY 2003 and FY 2002 funding continued the mid- to high-temperature low-cost SECA solid state fuel cell program; fund multiple SECA industrial teams and a core technology program; conduct coal-based SECA-hybrid integration studies as permitted. *Participants included: McDermott, ADL, NL, NETL.*

	(dollars in thousands)		
	FY 2002	FY 2003	FY 2004
■ **Program Support**	271	225	235

Fund technical and program management support.

Novel Generation	**0**	**2,500**	**2,500**

The current focus of the Novel Generation program is on the development of simple and powerful, low-cost, low-pollutant power systems based on ramjet technology called Ramgen, that can utilize a variety of fuels including greenhouse gases, and that can operate at high efficiencies for distributed generation and in a hybrid configuration for Vision 21 applications. To ensure the participation of high-potential technologies, the power systems group will continue to openly solicit new fossil-fuel based power generation technology that shows promise of improved efficiencies and/or lower emissions through the novel concepts program.

Novel Generation	**0**	**2,500**	**2,500**
■ **Supporting Technologies**	0	2,475	2,475

Continue to openly solicit new fossil-fuel based power generation technology that shows promise of improving efficiencies and/or lower emissions through the novel concepts program. *Participants to be determined.*

FY 2003 funding was used to issue a solicitation for novel generation systems. In FY 2002, this activity was carried out under the Turbines program. *Participants included: Ramgen.*

■ **Program Support**	0	25	25

Fund technical and program management support.

Total, Distributed Generation Systems	**56,678**	**49,500**	**47,000**

Explanation of Funding Changes

	FY 2004 vs. FY 2003 ($000)
Fuel Cells	
Advanced Research	
■ Increase in Advanced Research due to enhanced research on electrochemistry; direct carbon fuel cell development; and supporting research for SECA core technology program	6,930
■ Increase in Program Support will provide for detailed studies	70
Fuel Cell Systems	
■ Decrease in Fuel Cell Systems due to the completion of the FEC molten carbonate fuel cell stack development program (non-hybrids)	-3,960
■ Program Support	-40
Vision 21 Hybrids	
■ Decrease in Vision 21 Hybrids due to the completion of the SWPC SOFC module development program	-6,435
■ Decrease in Program Support due to reduced effort in market analyses	-65
Innovative Systems Concepts	
■ Increase in Innovative Systems Concepts due to initiation of designs for coal-based SECA systems	990
■ Program Support	10
Total Funding Change	**-2,500**